Empirical Analysis of Weaning and Pasture Rotation Frequency with Implications for Retained Ownership

Michael Popp,* K. Coffey, W. Coblentz, Z. Johnson, D. Scarbrough, J. Humphry, T. Smith, D. Hubbell, and J. Turner

ABSTRACT

The economic impact of rotation frequency (twice weekly vs. twice monthly until time of weaning) and time of weaning (early April vs. 56 d later) was examined for fall-calving cows using a modified put and take grazing strategy implemented to maintain equal grazing pressure across production systems. Cow and/or calf death losses resulted in replacements with either bred cows or cow–calf pairs. While the analysis on heifer calves was limited to sale at time of weaning, steer calves were tracked through the feedlot stage to determine if the time of sale would alter production system recommendations. For the conditions presented in this study, cow–calf producers may be advised that (i) relative to late weaning, early weaned calves did not regain their weight disadvantage observed at time of weaning; (ii) more intensive pasture management (rotating twice weekly rather than twice monthly) was not worth the effort because partial return results for late-weaned steer and heifer calves did not differ statistically by rotation frequency, regardless of sale time; (iii) partial returns were highest for steer calves retained through the finishing stage at the feedlot (regardless of production system) compared with sale at the time of weaning or at the time of placement in the feedlot; (iv) the range of returns or financial risk exposure increased with length of calf ownership. However, use of long-term average prices excluded input price risk from the analysis and output price risk was only partially addressed.

C OW–CALF PRODUCERS are often faced with the decision on when to wean (Myers et al., 1999a, 1999b) and/or at what time in the calf's life cycle to sell the herd's calves (Gill and Lusby, 2005; Marsh and Feuz, 2002; King-Brister, 2003). In the midsouthern USA, this decision can be somewhat complex, especially for producers using a fall-calving system. Calves can be weaned in early April to (i) allow for the weaning stress to occur during cooler temperatures; (ii) potentially sell calves at seasonally higher prices (King-Brister, 2003); and (iii) allow for additional grazing by other livestock or hay harvest. By the same token, weaning in late May or early June would delay weaning stress past the peak spring forage season which would allow for heavier weaning weights, albeit at seasonally lower prices. Further, if calves are retained through to the fall to be sold as yearlings to feedlots, how will early and late-weaned calves, pastured during the summer months, compare in terms of performance? Finally, if steer calves are retained through the finishing stage, what are the financial repercussions for the cow–calf producer, and second, will the cattle market send the same signal about what production system to use regardless of when the steer calves are sold?

A more basic question that may affect the above issues is how often to rotate pasture paddocks. Up to a point, a higher rotation frequency (holding stocking rate constant) is expected to allow for more optimal pasture utilization, thereby enhancing reproductive performance (Holechek et al., 1998), as well as beef production per acre (Walton et al., 1981; Bertelsen et al., 1993; Hoveland et al., 1997). However, individual animal performance may not be enhanced (Bertelsen et al., 1993; Hoveland et al., 1997; Barker et al., 1999; Lomas et al., 2000) or actually may be reduced (Volesky et al., 1990). Another benefit of more intensive forage management is improved forage persistence (Mathews et al., 1994; Hoveland et al., 1997). Lower rotation frequency, on the other hand, reduces investment in fencing and associated repair cost and is less management intensive.

The objectives of this 4-yr study were therefore to analyze (i) the impact of rotation frequency and weaning date of fall-born calves on economic performance per cow; (ii) identify the optimal sale time for steer calves (at time of early or late weaning, before placement in the feedlot in the fall, or at time of finish in the following spring); and (iii) determine whether production system recommendations change with the length of ownership of the steer calves.

MATERIALS AND METHODS

Experimental Description

Fall-calving 75% Angus × 25% Brangus cows were bred using a 100% Angus herd sire. These cows were stratified by weight and age and placed randomly on eleven pastures of varying size in April of 2000. While pasture size varied, the stocking rate of ≈0.9 cows ha^{-1} (resulting in four to six cows per pasture) was held constant across production systems. Using a randomized complete block design, pastures were divided by main effects of (i) rotation frequency (twice weekly using eight equally sized paddocks per pasture or twice monthly with two equally sized paddocks); and (ii) time of weaning (early April vs. 56 d later). Three replicates for each production system were used each year with the exception of the 8E system, where only two replicates were available due to lack of pasture availability in the first 2 yr (the 12th pasture was added in year 3).

M. Popp, Dep. of Agricultural Economics and Agribusiness, 217 Agriculture Building, and K. Coffey and Z. Johnson, Dep. of Animal Sci., AFLS B106, Univ. of Arkansas, Fayetteville, AR, 72701; W. Coblentz, USDA-ARS, U.S. Dairy Forage Research Center, Univ. of Wisconsin, Marshfield Agricultural Research Station, 8396 Yellowstone Dr., Marshfield, WI 54449; D. Scarbrough, 126 Jessie Dunn, Northwestern Oklahoma State Univ., Alva, OK 73717; J. Humphry, Humphry Environmental, Inc., Fayetteville, AR 72702; T. Smith and D. Hubbell, Univ. of Arkansas Livestock and Forestry Branch Stn., 70 Experiment Station Dr., Batesville, AR 72501; and J. Turner, North Carolina State Univ. Mountain Research Stn., Waynesville, NC 28786. Received 19 Dec. 2005. *Corresponding author (mpopp@uark.edu).

Abbreviations: CDF, cumulative distribution function; hd, head.

The pastures were located at the University of Arkansas Experiment Station near Batesville, AR (35°52′ N, 91°45′ W) on Clarksville (loamy-skeletal, siliceous, semiactive, mesic Typic Paleudults) and Gepp (very-fine, mixed, semiactive, mesic Typic Paleudalfs) very cherty silt-loam soils. These soils are characterized as being deep, somewhat excessively drained, having 8 to 40% slopes, and not adapted to tillage (Ferguson et al., 1982). Pastures consisted mainly of *Neotyphodium coenophialum*–infected tall fescue (*Festuca arundinacea* Schreb. L.; Coffey et al., 2005); they were fertilized and maintained according to recommendations of the University of Arkansas Cooperative Extension Service (Chapman, 2001). Pasture paddocks were only used for grazing, and excess forage during the spring peak growth period was managed by temporarily adding cull cows to pastures to control excess available forage. Depending on pasture treatment and size, this resulted in 43 to 49 d of grazing in 2000 and 14 to 22 d in 2001. The practice of adding cull cows during the spring period was discontinued for 2002 because (i) weather conditions were more droughty than expected, thereby reducing late-summer available forage below critical levels during 2000, and (ii) an armyworm (*Pseudaletia unipuncta* L.) infestation caused a shorter-than-expected grazing period in 2001.

Supplemental feeding during the winter months occurred in the form of tall fescue hay when available forage was limiting, and a corn–soybean meal supplement was fed during the 60-d breeding season. The corn–soybean meal supplement was formulated to maintain cows at their present body condition score (National Research Council, 1996), and was fed equally to each pasture group. Overall, the pasture management strategy across all treatments was to maintain consistent grazing pressure by adding or removing cull cows and/or adjusting for cow and calf death losses with cattle replacements (bred cows and/or cow–calf pairs as deemed similar to what a producer might do on a ranch).

All calves were weighed at both weaning dates. Heifer calves were either sold at time of weaning or retained for herd replacement. Once weaned, steer calves (castrated within 24 h of birth) were kept on separate pastures during the summer months without supplemental nutrition other than trace mineralized salt. They were weighed before shipment (beginning of October through mid-November) to a commercial feedlot in Kansas where they were offered a finishing ration in a common pen for 156, 187, and 203 d in 2001, 2002, and 2003, respectively.

Economic Analysis

A partial return analysis on a per-cow basis, accounting only for revenue and cost differences associated with weaning time, rotation frequency and time of calf sale was deemed appropriate for the following reasons: (i) differences in reproductive performance across production systems was negligible (Coffey et al., 2005) and could be accounted for by tracking cattle replacement costs as a result of breeding failure or death losses; (ii) the pastures were managed for consistent grazing pressure and thus the need to differentiate for production by unit of land was deemed unnecessary; (iii) calculation of actual profitability would not aid in differentiation across production systems; and (iv) accounting for death losses and calf sex differences requires fewer modifying assumptions on a per-cow rather than per-unit-of-land basis. Note that cost differences across systems included both operating and ownership charges.

Partial returns per cow are defined as calf and cull cow sales less cattle purchase, supplemental hay and feed, summer grazing, steer feedlot costs, cattle replacement, death loss, and prorated fencing and interest costs. These partial returns were further differentiated by sex of calf as the ratio of steer and heifer calves was inconsistent across production systems. The treatment with the highest partial returns would be preferred over its alternatives.

Calf and Cull Cow Sales

The 1996 to 2004 averages of monthly Arkansas and Kansas prices for calves, cull cows and replacement cows or cow–calf pairs were used depending on (i) weight of calf; (ii) sex of animal; (iii) pregnancy status and/or calf vs. no calf at side; and (iv) time and location of sale (Agricultural Marketing Service, 2005; Livestock Marketing Information Center, 2005). A 9-yr average monthly price was chosen to eliminate the effects of cyclically high or low cattle prices and because consistent price series for all prices were available for that period. All calf weight information was adjusted for 4% shrink to account for weight loss during transit and marketing. Since other marketing charges depend on trade terms and vary by location, they were not included in any of the treatment analyses. All cattle prices were adjusted for inflation using the seasonally unadjusted consumer price index to represent costs and returns in 2004 dollars (Bureau of Labor Statistics, 2005). Costs were representative for conditions in Arkansas in 2004.

Supplemental Hay and Rotational Fencing Charges

The amount of hay supplemented during winter months was recorded for each pasture to account for differences in feed costs that were expected as a result of differences in available stockpiled fescue (in turn a result of rotation frequency). Hay feeding costs were subsequently averaged by treatment and equally weighted across all years to remove the impact of unusually high or low feeding costs for any given year. The corn–soybean meal supplement was identical, regardless of treatment. Pastures with a higher rotation frequency required additional fencing and associated costs depend on the size of the cow herd, as well as the terrain of the pastures. Similar to King-Brister (2003), this analysis used (i) a capital recovery rate of 5%; (ii) a permanent five-strand barbed wire perimeter and two-strand electric cross-fence cost of $1.05 and $0.26 m^{-1}, respectively; (iii) a useful life of 20 yr with zero salvage value; (iv) a 40% repair cost factor[1]; and (v) an adjustment to fencing costs by adding 20% to account for terrain-based fencing (curves, hills, etc.). On a per-cow basis, the difference in capital and repair costs for two vs. eight paddocks was approximately $1.50 cow^{-1}. No other charges for the higher rotation frequency were assigned as they were deemed similar in terms of management & labor intensity as well as no observed effects on species composition (Coffey et al., 2005).

Adjustments for Time of Sale

Steer calves could be sold at (i) time of weaning in early April; (ii) 56 d later; (iii) as yearlings to the feedlot; or (iv) as finished cattle. To make partial returns per cow comparable across the aforementioned sale times, differences in summer grazing charges, capital returns foregone due to deferred sales, death losses, and feedlot charges of feed, insurance, and yardage were calculated. Table 1 presents a summary of feeding charges and opportunity cost adjustments necessary to calculate partial returns that conceptually would be achieved had all steer calves been sold by the time of slaughter. An early weaned steer would thus have investment returns from the

---

[1] The repair cost factor determines repair and maintenance cost as a percentage of original purchase price.

Table 1. Accounting for time of sale differences by adjusting for differences in feed and handling charges, foregone interest, and death losses on steer calves.

| | Time of sale† | | | |
Description	Early weaning	Late weaning	Feedlot	Finish
Revenue				
Steer Sale	**April**	**June**	**October/ November**	**April/May**
Investment returns‡	yes	yes	yes	no
Cost				
Supplemental hay, cow–calf replacement, and cull cow grazing returns§	yes	yes	yes	yes
56-d grazing¶	no	yes	no	no
Summer grazing#	no	no	yes	yes
Feedlot charges††	no	no	no	yes
Death losses‡‡	no	no	no	yes

† Early weaning occurred on 4, 10, and 9 April of 2001, 2002, and 2003, respectively. Late weaning was 56 d later than Early Weaning. Feedlot placement occurred on 12 Nov. 2001, 1 Oct. 2002, and 10 Nov. 2003. Cattle were finished on 17 Apr. 2002, 6 Apr. 2003, and 31 May 2004.

‡ Investment returns (5% per annum adjusted to a daily rate of 0.014% was used) represents potential income a producer would have earned by using the proceeds from cattle sales and investing until the time of final sale. Operating interest on half of the payments for feeding charges (grazing, veterinary, and incidental as well as feedlot charges) are subtracted, as payment of feed charges may occur at any point during the feeding period.

§ Supplemental hay fed during the winter, cow–calf replacement charges, and cull cow grazing returns are adjusted to a per-cow basis and are averaged to remove bias of excessively high or low hay consumption, cull cow performance, and/or cow–calf replacement costs.

¶ This charge represents the 56-d portion of a pasture fee of $18 hd^{-1} for the summer grazing season but not the veterinary and incidental charges of $12 hd^{-1}.

Summer grazing includes all of the $18 hd^{-1}, and veterinary and incidental charges of $12 hd^{-1}.

†† Feedlot cost (including feed, veterinary, insurance, and yardage) is adjusted on a per-animal basis according to weight gained.

‡‡ Preweaning death losses are hypothesized to be similar across treatment. Summer grazing losses did not occur and feedlot death loss costs were averaged across all placements.

proceeds of the sale that would be achieved from its time of sale until it would have been processed. Selling at the latest stage, by the same token, incurs a full charge of summer pasture, veterinary and incidental charges, death loss, feeding and operating interest charges, and no adjustment for foregone returns of capital.

Grazing Charges

Steer calves weaned in the spring were prepared for feedlot placement in the fall by grazing pasture during the summer months. All calves were commingled and grazed as a group in a rotational system utilizing predominantly bermudagrass [*Cynodon dactylon* (L.) Pers.] pastures. Costs associated with rotation frequency differences were therefore not maintained during this period and calves were also not supplemented to improve weight gain. The only summer grazing charges therefore included a pasture fee of $18 head^{-1} (hd) which represented mainly fertilizer, fuel, weed control, and operating interest (King-Brister, 2003). The fee was adjusted by length of stay to allow for differences in time of steer calf sale (i.e., for calves sold at weaning, late-weaned calves incurred part of the summer grazing fee whereas early weaned calves did not).

Estimation of Feedlot Charges

Kansas State University maintains an extensive database on average feedlot production costs as reported for thousands of head each month by commercial Kansas feedlots. Monthly

Table 2. Cost of Gain Regression Equation Results using 1996–2004 Feedlot Cost of Gain Data Reported for Commercial Kansas Feedlots.

Dependent variable: COG†	Coefficient	SE‡	Average
Independent variables			
C***	−29.7269	8.6078	
WGAIN**	−0.0225	0.0073	484.76
FCV***	9.7072	1.0708	6.07
CORN***	11.3977	0.3851	2.93
ALF**	0.0424	0.0129	96.36
Adj. R^2	0.9817		
SE of regression	1.3238		
Mean of COG	55.75		
F statistic***	1384.88		
No. of observations	104		

** Significant at the $P < 0.01$ level of significance.
*** Significant at the $P < 0.001$ level of significance.

† Variable descriptions are as follows: ALF was the deflated price of alfalfa hay in $ U.S. ton^{-1}; C was the constant term; COG was the average deflated cost of gain in $ lb^{-1} of weight added in the feedlot for a steer calf finished in a certain month; CORN was the deflated price of corn in $ bu^{-1} averaged across the previous 5 mo; FCV was the ratio of average weight of feed hd^{-1} (dry matter basis) per WGAIN; WGAIN was the average weight added to steers during their stay in the feedlot in lb hd^{-1}.

‡ Standard errors are adjusted for heteroskedasticity and autocorrelation using the Newey-West HAC option in EVIEWS 2.0 (Hall et al., 1995).

data from 1996–2004 allowed estimation of long-run average cost of gain as follows:

$$COG = f \text{ (WGAIN, FCV, CORN, ALF)} \quad [1]$$

COG in $ lb^{-1} of weight added in the feedlot was the reported average, deflated feedlot cost of feed, veterinary charges, insurance, and yardage for steer calves finished in a particular month (Livestock Marketing Information Center, 2005); WGAIN in pounds hd^{-1} was the average weight added to steers during their stay in the feedlot; FCV represented feed conversion and was the ratio of average weight of feed hd^{-1} (dry matter basis) per WGAIN; CORN was the average, deflated price of corn in $ bu^{-1} during the previous 5 mo; and ALF was the deflated price of alfalfa hay in $ U.S. ton^{-1}. Regression analysis, reported in Table 2, revealed that ≈98% of variation

Table 3. 1996 through 2004 monthly Arkansas average prices† for medium to large frame No. 1 feeder steers and heifers, cull cows,‡ second- and third-stage pregnant cows, and cow–calf pair prices for months of transactions used.

Weight category or animal type	Medium- to large-frame No. 1 feeder heifers			Medium- to large-frame No. 1 feeder steers		
	Apr.	May	June	Apr.	May	June
			$ kg^{-1}			
136–204 kg	2.21	2.16	2.14	2.54	2.47	2.45
205–227 kg	2.06	2.02	2.02	2.32	2.26	2.24
227–272 kg	1.93	1.91	1.92	2.13	2.09	2.08
273–318 kg	1.79	1.80	1.84	1.96	1.97	1.98
318–363 kg	1.68	1.72	1.76	1.82	1.83	1.88
	Jan.	Mar.	Apr.	June	Oct.	Dec.
Short bred or open replacement cow	0.97	1.03	1.03	1.01	0.98	0.99
3-6 mo. pregnant replacement cow	1.15	1.21	1.19	1.13	1.15	1.18
6-9 mo. pregnant replacement cow	1.26	1.33	1.31	1.26	1.23	1.3
			$ hd^{-1}			
Replacement cow with 45- to 91-kg calf at side	702.82	726.06	746.66	741.12	694.22	717.8

† All price and cost information is adjusted for inflation to 2004.

‡ Replacement cows are pregnancy tested or nursing a calf and weigh between 386 and 544 kg and are 2 to 8 yr old.

Table 4. 1996 through 2004 monthly average prices† for medium- to large-frame No. 1 feeder steers‡ and live cattle§ for months of transactions used.

Weight category	October	November
159–181 kg	2.53	2.59
182–204 kg	2.39	2.45
205–227 kg	2.31	2.37
227–249 kg	2.21	2.23
250–272 kg	2.10	2.09
273–295 kg	2.02	2.05
295–318 kg	2.05	2.02
318–340 kg	2.05	2.03
341–363 kg	2.03	2.01
363–386 kg	2.01	2.02
386–408 kg	1.95	1.91
409–431 kg	1.91	1.84
431+ kg	1.85	1.72

† All price and cost information is adjusted for inflation to 2004.
‡ Feeder steer prices are state averages for Kansas.
§ Prices for live cattle (free on board at the feedlot with a 4% pencil shrink) for five market areas of Texas/Oklahoma, Kansas, Colorado, eastern Nebraska, and Iowa/Minnesota were $1.72 kg^{-1} and $1.71 kg^{-1} for April and May, respectively. The prices are weighted by number of cattle, live weight, and averaged across cattle grade (LMIC, 2005).

Table 5. Probabilities of F values from Type III tests of fixed effects of weaning date, rotation frequency, and sale time as well as random effects of year and pasture replication on partial returns obtained from steer and heifer production obtained from SAS PROC MIXED analysis.

Effect	Steers	Heifers
	$P > F$	
Weaning date (W)	0.0005	<0.0001
Rotation frequency (R)	0.6987	0.7524
Sale time (T)	<0.0001	na†
W × R	0.0179	0.0815
W × T	0.3773	na
R × T	0.5827	na
W × R × T	0.8713	na

† Not available. Heifers were sold at time of weaning only whereas the steers were monitored to the time of placement in the feedlot and subsequently the time of cattle finish at the end of the feedlot phase.

in COG was explained by the independent variables. Further, changes in the average cost of gain were driven mainly by fluctuations in the price of corn in the feed ration (Pearson correlation coefficient between COG and CORN was 0.94) rather than changes in FCV, WGAIN, or ALF.

Since long-run average feedlot finishing costs, representative for Arkansas cattle typically shipped to Kansas, Oklahoma, or Texas feedlots, were not obtainable from this experiment, coefficients from Eq. [1] were used to approximate the cost of gain for individual steers on the basis of observed weight gain, holding all other values at the 1996 to 2004 averages (again adjusted for inflation).

Death Losses, Replacement Charges, and Cull-Cow Grazing Returns

Calf death losses occurred at or near time of fall calving and, in one instance, just before weaning. These losses were tracked by accounting for cattle replacement costs. There were no death losses during the summer grazing period. At the feedlot, four steers died in 2003. The value of these animals was approximated by averaging partial returns per cow at time of feedlot placement across all years and was deducted evenly from returns across all treatments.

Cattle replacement costs (sale, if any of the cull animal, less cost of replacement animal) as well as cull cow grazing returns (purchase cost less sale price in $ hd^{-1}) were totaled across all years and treatments and an average replacement cost or grazing return was assigned to the treatments that required cattle replacement and/or had cull cows grazing rather than assigning the individual animal's actual replacement cost and/or grazing return. This was done to guard against the impact

Table 6. Average production system statistics per cow by steer vs. heifer at time of weaning.†

	Heifer				Steer			
	2E	2L	8E	8L	2E	2L	8E	8L
Revenue								
Weight, kg hd^{-1}	217	261	208	271	221	273	222	281
Price, $ kg^{-1}	2.02	1.89	2.05	1.87	2.26	2.03	2.23	2.02
Investment return, $ hd^{-1}	22.04	21.32	21.54	21.70	25.35	23.93	25.56	24.66
Total revenue, $ hd^{-1}‡	441.25	492.09	427.08	507.54	500.44	552.56	496.97	566.31
Costs								
Supplemental hay, $ hd^{-1}§	77.29	76.55	80.51	77.04	77.29	76.55	80.51	77.04
Cow–calf replacement, $ hd^{-1}¶	7.26	6.57	10.16	6.83	7.26	6.57	10.16	6.83
Cull cow grazing, $ hd^{-1}#	0.23	0.28	0.18	0.24	0.23	0.28	0.18	0.24
56-d grazing, $ hd^{-1}	0.00	4.92	0.00	5.01	0.00	4.99	0.00	4.98
Rotational fencing, $ hd^{-1}	0.00	0.00	1.50	1.50	0.00	0.00	1.50	1.50
Total costs, $ hd^{-1}	84.78	88.32	92.35	90.62	84.78	88.38	92.35	90.58
Partial returns, $ hd^{-1}	356.47	403.77	334.72	416.92	415.66	464.18	404.62	475.73
CV of partial returns, %	8.6	15.1	10.4	8.1	11.5	10.0	10.1	10.4
Least squares means††	355.62b	403.87a	335.94b	417.66a	431.73bc	462.78ab	390.58c	487.13a

† The production system number indicates the number of paddocks and implies rotation frequency (2 is rotating twice monthly and 8 is rotating twice weekly) whereas the letter represents early (E) weaning in April vs. 56 d later (L). See Table 1 for description of cost and revenue items that encompass the different production systems. Number of head per treatment is presented in Fig. 1 and 2.
‡ Total revenue is adjusted for 4% shrink and investment returns. Since weights and prices vary per head the number is different from the average that could be calculated using the information in the table (i.e., prices were adjusted for weight category on an individual animal basis).
§ Hay consumption hd^{-1} can be derived by dividing the supplemental hay cost by its price ($0.025 lb^{-1}).
¶ During the period of the study, 4 and 5 cows or cow–calf pairs were replaced for each of 2E, 2L, 8L, and 8E, respectively. Note that the average cost of replacement was $85.35 hd^{-1}, which was further adjusted by the treatment cow numbers of 47, 52, 42, and 50 for 2E, 2L, 8E, and 8L, respectively.
# During the period of the study 18, 25, 13, and 20 cull cows were grazed for part of the spring peak season on 2E, 2L, 8E, and 8L, respectively. Note that the average loss per cull cow was $0.59 hd^{-1} (excluding marketing and transportation charges) which was further adjusted by the treatment cow numbers of 47, 52, 42, and 50 for 2E, 2L, 8E, and 8L, respectively.
†† Least squares mean partial returns for the same cattle sex followed by the same letter are not significantly different as determined by multiple t tests at the 10% level. Least squares means differ from the partial returns in the previous row since least squares means were calculated by first average individual cow partial returns by pasture and then across years compared with calculating the simple average across all individual cow partial returns.

of unusually high or low costs of low performance of individual animals assigned to the different treatments while still capturing quantitative performance differences across treatments (e.g., a particular treatment could have relatively more cattle replacements but the cost of each replacement was the same across treatments).

Cattle Price Data

Weekly and monthly price and cost information were adjusted for inflation and averaged by month over the period of 1996 to 2004 as necessary. Simple average prices for different weight categories and animal types are reported in Tables 3 and 4. Use of long-run average prices was deemed appropriate to highlight effects of production system differences by eliminating effects of unusually high or low cattle prices as a result of cattle cycles, price trends, and random events. Output price risk was thus captured in the sense that the time of cattle sales was associated with its appropriate seasonally adjusted long-run average price but input price risk was not reflected.

Risk Measurements

Annual partial return observations (in $ cow^{-1} for calves weaned or sold) were compared across systems by examining average partial returns as well as their empirical cumulative distribution functions (CDFs) constructed using Schlaifer's (1959) fractile method. This was done as visual examination of CDFs allows the reader their own unique interpretation of the riskiness of each of the production systems for heifer and/or steer production by time of sale by presenting minimum and maximum partial returns as well as the likelihood of attaining various levels of partial returns as compared to merely reporting the average and CV. Cumulative distribution functions with a narrower range of observations will be steeper than those with a wider range of observations and thus preferable to the risk-averse cattle producer. Further, the horizontal position of the CDF on the partial return scale allowed a comparison of return levels across the spectrum of return observations. Curves with observations furthest to the right would, at a given cumulative likelihood, experience the highest partial returns, and would therefore be deemed preferable to those that have observations to its left. Note, however, that a definitive statement about which production system a producer would choose is not possible using this analysis framework, as each individual producer may have different risk preferences.

Visual examination of the CDF analysis was complemented by testing for statistically significant differences across fixed effects of production systems (weaning date and rotation frequency) and time of sale (for steer calves only) using PROC MIXED in SAS (Littell et al., 1996). Year and pasture paddocks were treated as random effects and degrees of freedom were adjusted using the Satterthwaite option.

RESULTS

Rotation frequency, weaning date, and sale time are all significant either by themselves or as interactions at the 10% level of significance (Table 5). The overriding effect was weaning date and sale time for the steers and weaning date for the heifers. These results supported separate reporting of average performance statistics for the three fixed effects.

Table 6 and Fig. 1 provide a comparison of partial returns for steers vs. heifers at time of weaning. On the revenue side, weaning weights were lower for the early
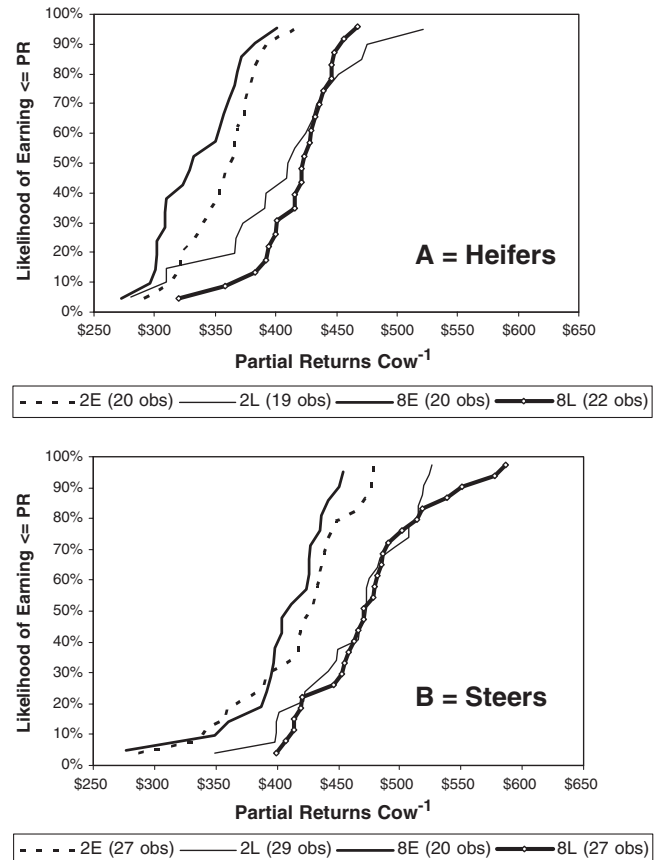

Fig. 1. Comparison of empirical cumulative distribution functions of partial returns per cow at time of weaning for heifers (Panel A = Heifers) and steers (Panel B = Steers) born in 2000 through 2002. Production systems are defined by the number of paddocks and implies rotation frequency (2 is rotating twice monthly and 8 is rotating twice weekly) whereas the letter represents early (E) weaning in April vs. 56 d later (L). The number of observations is presented in parentheses for each production system. PR = partial returns.

weaning date treatments for both heifers and steers as expected. This disadvantage was partially offset by higher prices for lighter weight calves sold earlier in the season. Increasing the rotation frequency had minimal impact on weaning weights of steers and numerically decreased weaning weight of heifers (2E vs. 8E). On the cost side, supplemental hay costs and cow–calf replacement costs did not follow a priori expectations. The highest feed bill and cow–calf replacement charges were incurred by the 8E system. This was likely due to stockpiled fescue losses incurred as a result of excessive winter rainfall and ice that affected the 8E system the most. Removing the impact of these costs, however, had little impact on the ranking of the production systems, and as a result this effect was considered of little consequence for subsequent analyses.[2] For both heifers and steers, the 8L system had highest average partial returns, and Fig. 1 revealed superior returns for most of the range of observations for both steers and heifers (CDF lies furthest to the right). Increasing the rotation frequency (8L) thus improved partial returns to the pro-

---

[2] Authors can be contacted for additional information.

Table 7. Average production system statistics per cow for steers sold at different stages in the supply chain.†

	Weaning				Feedlot				Finish			
	2E	2L	8E	8L	2E	2L	8E	8L	2E	2L	8E	8L
Revenue												
Weight, kg hd⁻¹	221	273	222	281	264	285	260	293	607	613	594	621
Price, $ kg⁻¹	2.26	2.03	2.23	2.02	2.14	2.08	2.16	2.10	1.72	1.72	1.71	1.72
Investment return, $ hd⁻¹‡	25.35	23.93	25.56	24.66	12.80	13.77	13.87	14.43	−5.68	−5.53	−6.00	−5.66
Total revenue, $ hd⁻¹	500.44	552.56	496.97	566.31	551.17	579.83	548.53	599.52	994.91	1005.40	971.56	1016.82
Costs												
Supplemental hay, cow–calf replacement, cull cow grazing, 56-d grazing, and rotational fencing, $ hd⁻¹	84.78	88.38	92.35	90.58	84.78	83.40	92.35	85.60	84.78	83.40	92.35	85.60
Summer grazing, veterinary and incidental charges, $ hd⁻¹	0.00	0.00	0.00	0.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Total feedlot cost and death loss, $ hd⁻¹§	0.00	na	na	na	0.00	0.00	0.00	0.00	392.00	379.15	383.30	380.83
Cost of gain, ¢ kg⁻¹¶	na	na	na	na	69.84	254.65	77.96	235.98	109.48	111.26	110.55	111.17
Total costs, $ hd⁻¹	84.78	88.38	92.35	90.58	114.78	113.40	122.35	115.60	506.77	492.55	505.65	496.43
Partial returns, $ hd⁻¹#	415.66	464.18	404.62	475.73	436.39	466.44	426.18	483.92	488.13	512.85	465.91	520.39
CV of partial returns, %	11.5	10.0	10.1	10.4	9.8	14.1	10.1	14.7	13.4	14.1	13.8	13.9
Least squares means#	431.73	462.78	390.58	487.13	449.56	467.03	421.70	500.32	501.65	511.57	454.31	539.01
Statistical ranking††	bc	ab	c	a	b	ab	c	a	b	ab	c	a

† The production system number indicates the number of paddocks and implies rotation frequency (2 is rotating twice monthly and 8 is rotating twice weekly), whereas the letter represents early (E) weaning in April vs. 56 d later (L). See Table 1 for description of cost and revenue items that encompass the different production systems. Number of head per production system is presented in Fig. 1 and 2.

‡ Investment returns are negative at the finishing stage as no investment returns are achieved and operating interest on feed costs is charged.

§ Four death losses occurred in 2003. The cost per head averaged $18.40. Feed ration, insurance, and yardage make up the remainder of charges.

¶ Cost of gain for the feedlot sale time was calculated as the summer grazing and veterinary and incidental charges per head divided by the weight gain for the summer grazing period. Cost of gain for the finish sale time is the average estimate of cost of gain during feedlot finishing. Interest is not included in the cost of gain figures.

Least squares means differ from the partial returns in the previous row since least squares means were calculated by first averaging individual cow partial returns by pasture and then across years compared with calculating the simple average across all individual cow partial returns for each production system.

†† Least square means of partial returns within the same time of sale followed by the same letter are not significantly different as determined by multiple t tests at the 10% level.

---

ducer mainly by way of higher weaning weight but this was not statistically significant when compared with 2L (Coffey et al., 2005).

Table 7 and Fig. 2 exhibit the comparison of partial returns by steer production system for different times of sale (weaning vs. feedlot vs. finish). On the revenue side, the late weaning systems showed the best performance
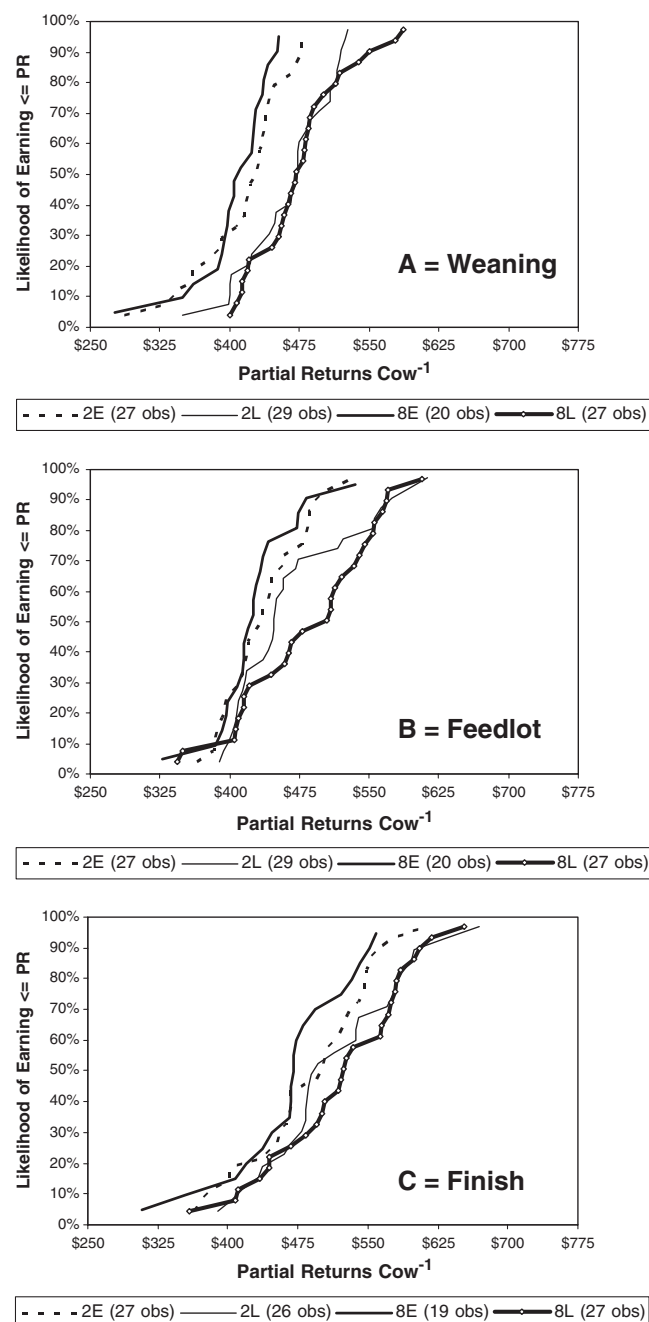
Fig. 2. Comparison of empirical cumulative distribution functions of partial returns per cow for steer calves born in 2000 through 2002 and sold at time of weaning (Panel A = Weaning) vs. time of feedlot placement (Panel B = Feedlot) and time of finish (Panel C = Finish). Production systems are defined by the number of paddocks and implies rotation frequency (2 is rotating twice monthly and 8 is rotating twice weekly) whereas the letter represents early (E) weaning in April vs. 56 d later (L). The number of observations is presented in parentheses for each production system. PR = partial returns.

regardless of sale time, although the gap in weight and revenue was largely closed between 2E, 2L, and 8L by time of cattle slaughter. At the same time, comparison of least squares means revealed that while the 8L system proved superior across sale times, the 2L system had statistically similar returns. This suggests, again, that the higher rotation frequency is not economically justifiable given also the reported lack of differences in relative pasture performance for this study (Coffey et al., 2005). As mentioned previously, failure of more intensive rotational management to improve individual animal gains is not uncommon (Volesky et al., 1990; Bertelsen et al., 1993; Hoveland et al., 1997; Barker et al., 1999; Lomas et al., 2000).

On the cost side, small weight gains for the late-weaned calves over the hot part of the summer grazing period lead to high cost of gain for the period between weaning and time of placement. Early weaned calf weight gains proved superior to late-weaned calf weight gains over this period mainly because early weaned calf gains included gains from the 56-d feeding period at the start of the summer grazing period that is associated with cooler seasonal temperatures. All calves, regardless of production system, were not managed for high rates of gain during the summer period and therefore experienced attractive feedlot performance likely due to compensatory weight gain.

Three other results are interesting. One, the range of return observations increased with the length of time that ownership on the calves was retained (CDF plots became flatter when moving from Panel A to Panel C in Fig. 2). Two, the statistical ranking (bottom row of Table 7) of production systems for the two best performing systems (8L and 2L) did not change with the time of sale. Three, retaining ownership through the finishing phase in the feedlot resulted in the highest partial returns regardless of pasture rotation frequency and weaning date ($P < 0.0149$). These improvements in partial return per cow by retaining ownership through the finishing phase compared with sale at time of weaning ranged from 9.4% (8L) to 17.4% (2E) or from \$44.66 (8L) to \$72.47 (2E).

CONCLUSIONS

Cow–calf producers facing similar conditions as those described in this study may be advised that (i) early weaned calves did not regain the weight disadvantage observed at time of weaning, relative to late-weaned calves; (ii) more intensive pasture management (rotating twice weekly rather than twice monthly) was not worth the effort because partial return results for late-weaned steer and heifer calves did not differ statistically by rotation frequency regardless of sale time; (iii) partial returns were highest for calves retained through the finishing stage at the feedlot (regardless of production system) compared with sale at time of weaning or time of placement in the feedlot; (iv) the range of returns or financial risk exposure increased with length of calf ownership (excluding input price risk and only partially accounting for output price risk).

The study could be improved by increasing the number of years of observations to be able to determine trends in beef and/or pasture production associated with rotation frequency and weaning time as well as the incorporation of observed price risk. Also, the study utilized an average five-market weighted average price for cattle sales at time of finish. This was deemed appropriate since calves were sourced from similar genetic backgrounds and fed using the same feedlot ration during the same period of time in the feedlot each year. Results may have differed with more observations, which might have allowed capturing more individual performance statistics. For example, steers might be fed for different periods in the feedlot each year and thereby finish with potentially different quality grades.

REFERENCES

Agricultural Marketing Service. 2005. Livestock and market news. USDA, Washington, DC.

Barker, J.M., D.D. Buskirk, H.D. Ritchie, S.R. Rust, R.H. Leep, and D.J. Barclay. 1999. Intensive grazing management of smooth bromegrass with or without alfalfa or birdsfoot trefoil: Heifer performance and sward characteristics. Prof. Anim. Sci. 15:130–135.

Bertelsen, B.S., D.B. Faulkner, D.D. Buskirk, and J.W. Castree. 1993. Beef cattle performance and forage characteristics of continuous, 6-paddock, and 11-paddock grazing systems. J. Anim. Sci. 71:1381–1389.

Bureau of Labor Statistics. 2005. Bureau of Labor Statistics Data—Consumer Price Index—All Urban Consumers. Available at www.bls.gov/cpi/home.htm [accessed 2 July 2005; verified 1 Mar. 2007]. U.S. Dep. of Labor, Washington, DC.

Chapman, S.L. 2001. Soil test recommendations guide. No. AGR 9. Cooperative Extension Service and Agric. Exp. Stn., Univ. of Arkansas. Little Rock.

Coffey, K.P., W.K. Coblentz, D.A. Scarbrough, J.B. Humphry, B.C. McGinley, J.E. Turner, T.F. Smith, D.S. Hubbell, III, Z.B. Johnson, D.H. Hellwig, M.P. Popp, and C.F. Rosenkrans, Jr. 2005. Impact of rotation frequency and weaning date on forage measurements, and growth performance by cows and calves grazing endophyte-infected tall fescue pastures overseeded with crabgrass and legumes. J. Anim. Sci. 83:2684–2695.

Ferguson, D.V., J.S. Lowrance, and C.E. McFadden. 1982. Soil survey of Independence Co., AR. USDA, Soil Conservation Service.

Gill, D., and K. Lusby. 2005. Evaluating stocker and cattle feeding retained ownership. Available at www.tcfa.org/ValuedAdded/4valuad.pdf [Accessed 29 June 2005; verified 1 Mar. 2007]. Texas Cattle Feeders Assoc., Amarillo.

Hall, R.E., D.M. Lilien, G. Sueyoshi, R. Engle, J. Johnston, and S. Ellsworth. 1995. EViews: User guide. Quantitative Micro Software, Irvine, CA.

Holecek, J.L., R.D. Pieper, and C.H. Herbel. 1998. Range management: Principles and practices. 3rd ed. Prentice Hall, Upper Saddle River, NJ.

Hoveland, C.S., M.A. McCann, and N.S. Hill. 1997. Rotational vs. continuous stocking of beef cows and calves on mixed endophyte-free tall fescue-bermudagrass pasture. J. Prod. Agric. 10:245–250.

King-Brister, S.K. 2003. Budgeting Arkansas beef cattle performance through alternative marketing and production strategies. Department of Agricultural Economics and Agribusiness. M.S. Thesis. Univ. of Arkansas, Fayetteville.

Littell, R.C., G.A. Milliken, W.W. Stroup, and R.D. Wolfinger. 1996. SAS system for mixed models. SAS Institute, Cary, NC.

Livestock Marketing Information Center. 2005. Available at www. lmic.info [accessed 25 May 2005. Verified 1 Mar. 2007]. LMIC, Washington, DC.

Lomas, L.W., J.L. Moyer, G.A. Milliken, and K.P. Coffey. 2000. Effects of grazing system on performance of cow–calf pairs grazing bermudagrass pastures interseeded with wheat and legumes. Prof. Anim. Sci. 16:169–174.

Marsh, J.M., and D.M. Feuz. 2002. Retained ownership of cattle: Factors to consider. Managing for today's cattle market and beyond. March 2002. Available at http://ag.arizona.edu/arec/wemc/cattlemarket/Retained_Ownership.pdf [posted March 2002; accessed 29 June 2005; verified 1 Mar. 2007]. Univ. of Arizona, Tucson.

Mathews, B.W., L.E. Sollenberger, and C.R. Staples. 1994. Dairy heifer and bermudagrass pasture responses to rotational and continuous stocking. J. Dairy Sci. 77:244–252.

Myers, S.E., D.B. Faulkner, F.A. Ireland, L.L. Berger, and D.F. Parrett. 1999a. Production systems comparing early weaning to normal weaning with or without creep feeding for beef steers. J. Anim. Sci. 77:300–310.

Myers, S.E., D.B. Faulkner, F.A. Ireland, and D.F. Parrett. 1999b. Comparison of three weaning ages on cow–calf performance and steer carcass traits. J. Anim. Sci. 77:323–329.

National Research Council. 1996. Nutrient requirements of beef cattle. 7th ed. National Acadamies Press, Washington, DC.

Schlaifer, R. 1959. Probability and statistics for business decisions: An introduction to managerial economics under uncertainty. McGraw-Hill, New York.

Volesky, J.D., J.K. Lewis, and C.H. Butterfield. 1990. High-performance short-duration and repeated-seasonal grazing systems: Effects on diets and performance of calves and lambs. J. Range Manage. 43:310–315.

Walton, P.D., R. Martinez, and A.W. Bailey. 1981. A comparison of continuous and rotational grazing. J. Range Manage. 34:19–21.